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TRAGOVI ALATA U ANTIČKIM I SREDNJOVJEKOVNIM KAMENOLOMIMA DALMACIJE KAO POMOĆ PRI KRONOLOŠKOM DETERMINIRANJU POJEDINIH FAZA EKSPLOATACIJE

Autor u radu razrađuje mogućnost postojanja određenih razlika u tragovima kamenarskih alata unutar antičkih, srednjovjekovnih, a dijelom i ranonovovjekovnih kamenoloma. Spomenuti tragovi očituju se u obliku strija na liticama eksploatiranih dijelova kamenoloma. Na temelju analize kamenoloma koji sadrže dovoljno elemenata za pobližu dataciju, autor zaključuje da postoje značajne razlike između antičkih i srednjovjekovnih kamenoloma i to u gustoći, smjeru i dubini strija te značajnije razlike u tlocrtu i načinu širenja kamenoloma.

KLJUČNE RIJEČI: *kamenarske tehnike, kamenolomi, tragovi alata, Dalmacija*

TOOL TRACES IN THE CLASSICAL ANTIQUITY AND MEDIAEVAL QUARRIES OF DALMATIA AS AN AID IN THE CHRONOLOGICAL DEFINITION OF INDIVIDUAL STAGES OF EXPLOITATION

This paper analyses the possibility of the existence of certain differences in the traces of quarrymen's tools in Classical Antiquity, mediaeval, and certain early modern era quarries. The aforementioned traces are evident in the form of striae on rocks in the exploited parts of the quarries. Based on analyses of quarries containing a sufficient amount of elements for closer dating, the paper concludes that there are significant differences between Classical Antiquity and mediaeval quarries in terms of the density, direction and depth of the striae, as well as important differences in the layout and expansion of the quarries.

KEY WORDS: *stone masonry techniques, quarries, tool traces, Dalmatia*

Prostor današnje Dalmacije obiluje vidljivim ostacima starih kamenoloma. Prve, jasno vidljive, eksploatacijske zone primjetne su u kamenolomima za izgradnju megalitskih bedema iz razdoblja od nekoliko stoljeća prije Krista. Najveći kamenolomi otvaraju se upravo u razdoblju potpadanja cjelokupnog prostora hrvatske obale pod rimsku upravu. Prekid je uvjetovan upadom barbarskih skupina u 6. stoljeću, međutim može se reći da se intenzivnija upotreba arhitektonskoga kamena nastavlja u razvijenom srednjem vijeku, sve do danas. Cilj ovoga istraživanja je: analizom vidljivih faza kamenoloma koji daju najbolju dataciju pokušati odrediti eventualne razlike u kamenarskoj tehnici, tj. utvrditi eventualne razlike u tragovima alata koji se prepoznaju na preostaloj stijenskoj masi.

The area of present-day Dalmatia is rich in the visible remains of old quarries. The first, clearly visible areas of exploitation can be seen in quarries exploited for the construction of megalithic fortification walls from several centuries BC onwards. The largest quarries were opened in the period when the entire Croatian coastal area came under Roman rule. Their exploitation ceased with the invasion of Barbarian groups in the 6th century. However, the intense use of architectural stone has continued from the High Middle Ages up to the present. The aim of this study, based on an analysis of the visible stages of the quarries which provide the best dating, is to try to classify possible differences in quarrying techniques, i.e. to identify possible differences in the tool traces recognisable in the remaining rock mass.

Početkom trećeg tisućljeća prije Krista, za vrijeme Prve egipatske dinastije, moguće je da su započeli prvi kamenarski radovi u ležištima vapnenca na istočnoj obali Nila u blizini grada Memfisa, a taj fini bijeli vapnenac korišten je za gradnju grobnica.[1]

Za vrijeme Druge dinastije pojavljuju se pažljivo oblikovani vapnenački blokovi, korišteni u gradnji grobnica, no u vrijeme iste dinastije počinje i upotreba većih granitnih blokova.[2] Tijekom Četvrte i Pete dinastije dokazano je i sustavno vađenje bazaltnih blokova.[3] Kamenarstvo, u svojem punom značenju, započinje umjetnim odvajanjem velikih blokova od matične stijene, reguliranim procesom tehnike uklesavanja kanala oko željenog bloka kojim se blok odvaja od matične stijene, a najbolji primjer je eksploatacija na ravnom terenu kada se formira mreža kanala koji učinkovitije iskorištavaju uloženu energiju kamenara.[4] Kanal kojim se odvaja kameni blok u većini krajeva današnje Dalmacije naziva se pašarin. Izraz „pašarin“ koristit će se i u ovom radu.

Tehnika uklesavanja pašarina oko željenog bloka na hrvatskoj obali i otocima započinje potpadanjem ovih krajeva pod rimsku upravu. Još nije potpuno jasno jesu li se i grčki kolonizatori na južnodalmatinskim otocima služili ovom tehnikom. Dokaze o korištenju kamenoloma iz doba grčke kolonizacije u Dalmaciji nalazimo u uvali Srebrena na otoku Visu, gdje je u otpadnim gomilama pronađeno više ulomaka keramičkog materijala koji se može datirati u 3. stoljeće prije Krista.[5] Arheološki materijal iz Srebrene na Visu nesumnjivo je dokaz korištenja kamenoloma u 3. stoljeću prije Krista, no zbog moguće identične tehnike eksploatacije teško je razdijeliti helenistički dio od, nešto kasnijega, rimskog dijela kamenoloma.

Općenito gledajući potpuna primjena tehnike odvajanja kanalima započinje na prostoru Dalmacije dolaskom pod rimsku upravu, no ona traje i kroz cijeli srednji, ali i novi vijek, kada se katkad javlja u kombinaciji s drugim tehnikama koje uključuju ručna svrdla, barut te željezne klinove za odvajanje nepravilnih kamenih blokova.

At the beginning of the third millennium BC, during the first Egyptian Dynasty, possibly the first quarry works commenced in the limestone layers on the eastern banks of the Nile in the vicinity of the town of Memphis. The fine white limestone was used for the construction of tombs.[1]

During the Second Dynasty, carefully shaped limestone blocks appeared and were also used in the construction of tombs. In the course of the same dynasty, the quarrying of larger granite blocks started.[2] The systematic quarrying of basalt blocks has also been confirmed during the Fourth and Fifth Dynasties.[3] Quarrying in its full sense started with the artificial separation of large blocks from the parent rock in a controlled process using the technique of cutting a channel around the desired block to separate it from the parent rock. The best example is exploitation on a flat surface, when a network of channels is formed to utilise the energy of the stonecutter more efficiently.[4] The channel used to separate stone blocks from the rock in most of the regions of present-day Dalmatia is called a *pašarin* in Croatian.

The technique of chiselling a *pašarin* around the desired block on the Croatian coast and islands started after they had come under Roman rule. It has still not been completely clarified whether Greek colonists on the southern Dalmatian islands also used this technique. Evidence of the use of quarries from the period of Greek colonisation in Dalmatia has been found in Srebrena Bay on the island of Vis, where several shards of pottery artefacts that can be dated to the 3rd century BC were unearthed in rubble heaps.[5] Archaeological artefacts from Srebrena on Vis undoubtedly confirm the use of quarries in the 3rd century BC. However, due to possible identical exploitation techniques it is hard to distinguish between the Hellenistic part of the quarry and its somewhat later Roman counterpart.

Generally speaking, the technique of separating blocks with channels started to be applied in Dalmatia after it had come under Roman administration but also took place throughout the Middle Ages, as well as in the modern era, where it sometimes occurs combined with other techniques, which include hand drilling, gunpowder, and iron wedges for separating irregular stone blocks.

1 M. WAELKENS, 1992, 6.
2 M. WAELKENS, 1992, 5.
3 E. BLOXAM, P. STOREMYR, T. HELDAL, 2009, 198.
4 M. WAELKENS, 1992, 6.
5 M. KATIĆ, 2009, 33.

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4 M. WAELKENS, 1992, 6.
5 M. KATIĆ, 2009, 33.

Valja naglasiti kako su kamenolomi vrlo problematični za datiranje iz nekoliko razloga. Često se u izvornim antičkim kamenolomima u kasnijim razdobljima vadio kamen, a u nekim slučajevima su se potpuno uništili tragovi originalnoga kamenoloma.

Ono što je važno za poznavanje problematike vađenja kamena jest i činjenica da hrvatska obala jadranskog mora sadrži mnoštvo očuvanih kamenoloma, važna je i neurbaniziranost i zaštićenost otoka, a sačuvano je i mnoštvo arhivskih podataka. Sveukupno, očuvani su dobri elementi za precizniju dataciju određenih kamenoloma.

Ako se sagleda tehnika vađenja arhitektonskog vapnenca pašarinima, može se reći da postoje tri osnovne faze: prva je faza rimske uprave i kasne antike, druga je srednjovjekovna faza, a treća je novovjekovna faza. Karakteristično za sve faze, kada je riječ o vađenju kvalitetnoga arhitektonskog vapnenca, je da se primjenjuje tehnika odvajanja kamenih blokova kanalima, općenito gledajući od antike do pojave helikoidne žice za strojnu eksploataciju sredinom 20. stoljeća.

Analizom više od četrdeset kamenoloma raspoređenih duž dalmatinske obale i otoka, došlo se do zaključka kako tragovi alata koji su sačuvani na stijenama kao posljedica vađenja blokova pašarinima, bez obzira na sličnosti, ipak pokazuju određene specifičnosti u gustoći, smjeru te dubini iskopa. S druge strane primjetne su i određene razlike u tlocrtu pojedinih kamenoloma iz kojih se mogu iščitati i razlike u načinu i intenzitetu eksploatacije.

Iako većinu obrađenih kamenoloma nije moguće precizno datirati, nekoliko ih se može precizno datirati na temelju arheoloških predmeta, infrastrukturnih objekata, i naposljetku, uz pomoć arhivskih podataka. Upravo su kamenolomi s najpreciznijom datacijom u ovom radu korišteni kao najbolji argumenti za donošenje pojedinih zaključaka.

Jedan primjer iz velikih kamenoloma Sv. Ilije kod grada Trogira, čiju kvalitetu ističe i Plinije (*Naturalis Historia*, III, 141), potaknuo je na pretpostavku o postojanju mogućnosti da tragovi alata na preostaloj litici kamenoloma mogu određivati starost eksploatacije. Na fotografiji na Sl. 1. su jasno vidljivi tragovi različitih alata i tehnika, jedni nasuprot drugima. Na fotografiji s lijeve je strane vidljiva litica starije, vjerojatno antičke faze kamenoloma. Na prvi pogled vidljiva je starija patina na stijenskoj masi, zatim tragovi pašarina koji govore o težim alatima korištenim u eksploataciji, smjer

It should be pointed out that quarries are very problematic in terms of dating for several reasons. Stone frequently continued to be extracted from original antique quarries in later periods, and in some cases traces of the original quarries were completely destroyed.

In discussing the issue of stone extraction, it should be emphasised that the Croatian Adriatic coast contains a number of preserved quarries. They are in non-urban, sheltered areas, and numerous archive data have been preserved. As a result, important elements for the precise dating of certain quarries have survived.

We can say that the technique of extracting architectural limestone by using channels falls into 3 basic periods: the Roman and Late Antiquity stage, the mediaeval stage, and the modern era stage. When it comes to extracting high-quality architectural limestone, a typical technique used in all stages, from the Classical Antiquity period until the appearance of helicoid wire for exploitation by machine in the mid-20th century, is that of separating stone blocks with channels.

An analysis of more than 40 quarries along the Dalmatian coast and islands suggests that the tool traces preserved on rocks as a result of extracting blocks by using channels, regardless of their similarities, also demonstrate certain specific traits, such as the density, direction and depth of the quarrying. On the other hand, certain differences in the layout of individual quarries are noticeable, which suggests different methods and intensity of exploitation.

Although most of the studied quarries cannot be precisely dated, several quarries can be chronologically determined based on archaeological artefacts, infrastructural features, and finally the help of archive data. In this paper, the quarries with the most precise dating were used as the strongest arguments for drawing certain conclusions.

An example from the large quarry of Sveti Ilija [St. Elijah] near the town of Trogir, whose quality was even mentioned by Pliny (*Naturalis Historia*, III, 141), supported the assumption that the tool traces on the remaining quarry rocks could possibly be the key to determining the period of exploitation. In the photo (Fig. 1), the traces of different tools and techniques, one set opposite the other, are clearly visible. On the left side of the photo, an older, probably classical antique phase of the quarry is visible. At first glance, an older patina is visible on the rock mass itself, as well as traces of the channel (*pašarin*), suggesting heavier tools being used in the exploitation. The direction of movement is always from left

Sl. 1. / Fig. 1.
Pogled na sjevernu i južnu liticu kamenoloma Sv. Ilija s vidljivim tragovima alata (foto: M. Parica).
View of the northern and southern face with visible tool traces (photo by M. Parica).

kretanja je uvijek slijeva nadesno, a strije govore i o izradi vrlo dubokih pašarina u jednom sloju.

Litica na Sl. 1. na desnoj strani ima sasvim drugačije odlike. Patina na stijeni je manje izražena, strije na litici kamenoloma su znatno gušće, pašarini su plići (oko 30 cm) te je jasno vidljiva promjena smjera koja govori o smjeru uklesavanja pašarina; jedan sloj u jednom smjeru, a drugi sloj u drugom. Ova promjena u smjerovima dokazuje i da je lijevi dio kamenoloma već bio iskorišten, a na sadašnjoj granici završetak mu je vjerojatno bio u obliku pravog kuta. Promjenu smjerova omogućuje otvoreni prostor starijeg kamenoloma. Ovaj primjer je dokaz o dvije faze kamenoloma koje, iako dijele istu tehniku ručnoga kopanja kanala, pokazuju razliku u gustoći tragova alata na litici kamenoloma te dubinu pašarina koji se kopa u jednom sloju.

Spomenuti podaci naveli su i autora ovoga teksta da uz pomoć eksperimenta provjeri tragove alata različitih težina koji ostaju na kamenu pri ekstrakciji kamenog bloka. Unutar jednoga deva-

to right, while the striae also indicate extraordinarily deep channels in one layer.

The face on the right side in Figure 1 is entirely different. The rock patina is less pronounced, the striae on the face of the quarry are significantly denser, the channels are flatter (approximately 30 cm), and a change in the direction of chiselling the channel is clearly visible: there is a layer stretching in one direction, followed by another stretching in another. The change in direction also confirms that the left part of the quarry had already been used, and at the present border its ending probably formed a right angle. The change in direction is made possible thanks to the open area of the older quarry. This example represents evidence of two phases in the quarry which, although using the same technique of manually digging channels, demonstrate a difference in the density of the tool traces on the face of the quarry and the depth of the channel dug in a particular layer.

The mentioned data led the author of this paper to conduct an experiment, checking the traces of tools of various weights that remain on the stone when extract-

Sl. 2. / Fig. 2.
Tragovi strija od dvošilja težine dva kilograma (foto: M. Parica).
Traces of striae from a two-spiked 2-kg hammer (photo by M. Parica).

stiranog kamenoloma arhitektonskog vapnenca kanalima je izdvojen kameni blok s tri strane. Dimenzije bloka su 45 x 75 cm, a dubina kanala je 45 cm. U ovom eksperimentalnom radu korišteni su čekići sa šiljkom različite težine. Alat težine dva kilograma korišten je za izradu pašarina s jedne strane kamenog bloka (Sl. 2.), a teži dvošilj od šest kilograma korišten je za kopanje pašarina s preostale strane bloka (Sl. 3.). Tragovi koji su ostali na litici jasno pokazuju da različita težina alata ostavlja vidno drugačije tragove na stijeni. Čekić od dva kilograma ostavlja puno gušće tragove strija od čekića od šest kilograma, a i strije lakšeg čekića su ravne, dok teži dvošilj radi strije koje imaju određenu zakrivljenost. Iako je duljina na kojima se mogu mjeriti strije suviše mala, može se okvirno odrediti broj strija u dužnome metru. Lakši čekić ostavio je okvirno 30 do 40 strija na dužnome metru, dok je teži ostavio od 15 do 20.

ing a stone block. In a devastated architectural limestone quarry, a stone block was separated by channels on three sides. The dimensions of the block were 45 x 75 cm, and the depth of the channel was 45 cm. For this experiment, hammers with spikes of various weights were used. Those lighter than 2 kilogrammes were used to make a channel on one side of the stone block (Fig. 2). A heavier two-spiked hammer, weighing 6 kilogrammes, was used for hammering a channel on the remaining side of the block (Fig. 3). The traces that remained on the face clearly demonstrate that tools of different weights leave different traces in the rock. A 2-kg hammer leaves much denser traces than a 6-kg hammer, and the striae of the lighter hammer are straight, while the heavier two-spiked hammer produces somewhat curved striae. Although the striae can only be measured over a short distance, it is possible to approximately classify the number of striae in a linear metre. The lighter hammer left approximately 30 to 40 striae per linear metre, while the heavier one left 15 to 20.

Sl. 3. / Fig. 3.
Kameni blok odvojen pašarinima (foto: M. Parica).
Stone block separated by channels (pašarini) (photo by M. Parica).

Metoda mjerenja broja strija na liticama kamenoloma podrazumijeva nekoliko čimbenika koji se moraju uzeti u obzir. Strije se mjere na središnjim (glavnim) dijelovima litice kamenoloma, tj. na dijelovima koji zasigurno pripadaju određenoj fazi eksploatacije, dok se periferni dijelovi, na kojima je često vidljivo vađenje samo jednog bloka, ne uzimaju u obzir jer su se iz antičkih i srednjovjekovnih kamenoloma u novom vijeku često vadili pojedinačni blokovi za izradu spremnika (kamenica) za držanje maslinova ulja.

Okomito na strije mjeri se broj ispupčenja ili ulegnuća u dužini od jednog metra (Sl. 4.). Ako nigdje na litici ne postoji kvalitetno vidljiv segment od jednog metra, mogu se mjeriti i manje dužine te se množenjem može doći do odgovarajuće vrijednosti. Iz željenog segmenta kamenoloma bolje je uzeti više mjerenja te na kraju odrediti središnju prosječnu vrijednost. Pri mjerenju je važno izbjegavati početne, gornje dijelove izrade pašarina, zatim izbjegavati završne i kutne segmente. I nadalje, ne

When measuring the number of striae on the faces of the quarry, several factors need to be considered. The striae are measured on the central parts of the face of the quarry, on parts which definitely belong to a certain exploitation phase, while the peripheral parts, in which frequently the extraction of only one block is visible, are not taken into consideration, since classical antique and mediaeval quarries were often exploited in the modern era for extracting individual blocks for the construction of stone containers for olive oil storage.

Vertically to the striae, a number of protrusions or hollows of one metre in length are measured (Fig. 4). If there are no clearly visible segments of one metre on a face, then smaller lengths can also be measured and multiplied in order to reach a corresponding value. It is advisable to take several measurements in the desired quarry segment, and in the end determine the mean value. While measuring, it is important to avoid the initial, upper parts of the channels, as well as the ends and corner segments.

Sl. 4. / Fig. 4.
Tragovi strija na litici kamenoloma (foto: M. Parica).
Traces of striae on the face of a quarry (photo by M. Parica).

mjeriti pozicije na litici kamenoloma gdje je vidljivo popravljanje pašarina. Idealni su dijelovi s jasno vidljivim pravilnim strijama na litici kamenoloma.

Da bi dobiveni rezultati imali znanstvenu vrijednost, u precizniju analizu uvršteni su isključivo lokaliteti, ili dijelovi lokaliteta, koji imaju preciznu dataciju. U ovu skupinu ubrajaju se lokaliteti: otočić Kamenjak kod Ista, Otavac kod Popovića, Ovča na Dugom otoku, Suva lokva kod Žaborića, Sv. Ilija kod Trogira i otočić Vrnik kod Korčule.

IST – KAMENJAK

Kamenjak je otok na otvorenom moru (Sl. 5), južno od otoka Ista te zapadno od otoka Molata. Na njemu se jasno razabiru ostaci šest pojedinačnih kamenoloma iz različitih razdoblja. Otok je građen od vrlo kvalitetne sirovine arhitektonskog poluprozirnog vapnenca koji izgledom podsjeća na mramor.

Kamenolom označen brojem 1 (Sl. 6.) smješten je na središnjem dijelu sjeverne obale Kamenjaka,[6] a riječ je o kamenolomu s pravilnim tlocrtom veličine cca 7 x 7 m. Sačuvane su i pravilne okomite stranice, a na dnu kamenoloma vidljivi su i tragovi kanala od pašarina. Specifičnost kamenoloma 1 je u tome što se dno eksploatacijskog otkopa nalazi oko 130 cm ispod današnje prosječne morske razine (Sl. 7.). Dio kamenoloma na morskoj strani je na razini dna otvorenog kopa pa su udari morskih valova odnijeli sav kameni materijal s baze te je ona

6 Prvi pregled 2000. godine: S. GLUŠČEVIĆ, 2001, 46.

In addition, measuring the position on a face where repairs to the channel are visible should be avoided. The ideal parts for measuring are those with clearly visible regular striae on the quarry face.

In order for the obtained results to have scientific validity, the analysis only included sites, or parts of sites, which have a precise dating. This group includes the following sites: Kamenjak near the island of Ist, Popovići in Otavac, Ovča on Dugi Otok, Suva Lokva in Žaborić, Sveti Ilija in Trogir, and Vrnik off Korčula.

IST – KAMENJAK

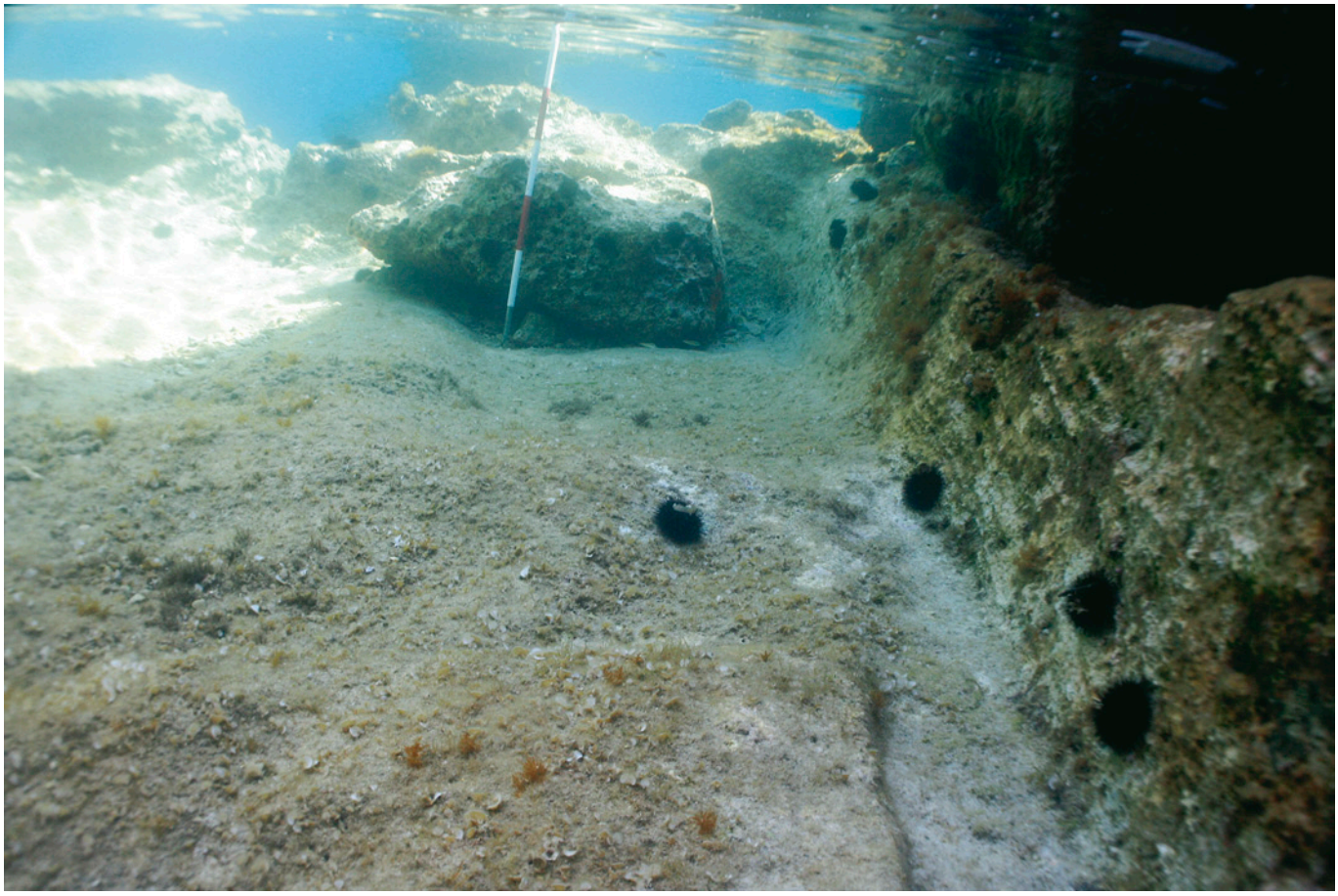
Kamenjak is an island situated in the open sea (Fig. 5), south of the island of Ist and west of the island of Molat. The remains of six individual quarries from different periods can be clearly identified. The island is constituted of high quality architectural semi-transparent limestone, the appearance of which is reminiscent of marble.

The quarry, marked with 1 (Fig. 6), is situated in the central part of the northern coast of Kamenjak.[6] It is a quarry with a regular layout, approximately 7 x 7 m. Regular vertical sides have been preserved, and at the very bottom of the quarry, traces of the channels are also visible. The specific feature of quarry 1 is that the bottom of the exploitation dig is situated approximately 130 cm below the present-

Sl. 5. / Fig. 5.
Satelitska snimka otoka Kamenjak (izvor: Arkod).
Satellite image of the island of Kamenjak (source: Arkod).

6 The first survey in 2000: S. GLUŠČEVIĆ, 2001, 46.

Sl. 6. / Fig. 6.
Kamenolom 1 na Kamenjaku (foto: M. Parica).
Quarry 1 on Kamenjak (photo by M. Parica).



Sl. 7. / Fig. 7.
Dio kamenoloma 1 na Kamenjaku koji se nalazi ispod razine mora s vidljivim dnom pašarina te strijama na litici kamenoloma (foto: M. Parica).
Part of Quarry 1 on Kamenjak, which is below sea level, with the visible bottom of the channel and with striae on the face (photo by M. Parica).

Sl. 8. / Fig. 8.
Tragovi korištenja eksploziva i kunjere u kamenolomu 2 na Kamenjaku (foto: M. Parica).
Traces of the use of explosives and grooves (kunjera) in quarry 2 on Kamenjak (photo by M. Parica).

ostala vidljiva. Zahvaljujući spomenutom procesu, vidljivi su i tragovi pašarina kojim su izolirani kameni blokovi, a na liticama su na pojedinim mjestima očuvani tragovi strija od dvošilja. S obzirom na pravilnost kvadratnog tlocrta, korištenje isključivo pašarina za ekstrakciju blokova te činjenicu da je dno kamenoloma 1,3 m ispod današnje morske razine, kamenolom 1 na Kamenjaku može se datirati u vrijeme antike.

Kamenolom 2 (Sl. 8.) se nalazi tridesetak metara zapadno od kamenoloma 1. Litice su nepravilne te se jasno vide ostaci rupa od ručnog svrdla i naprsline stijene kao posljedica korištenja baruta. Slika 8. prikazuje trag ručnog svrdla i horizontalnu kunjeru (utor „V“ oblika) nastalu nakon lomljenja stijene barutom. Otpadni materijal razbacan je u podnožju spomenutih ostataka. Na temelju korištenja baruta, kamenolom 2 može se datirati u razdoblje novog vijeka.

day average sea level (Fig. 7). The part of the quarry situated on the coastal side is at the level of the bottom of the open dig, so that the waves have swept away all the stone material, thus uncovering the base. As a consequence of this process, the traces of channels used for isolating stone blocks are also visible, and on the faces, in certain spots, traces of striae from two-spiked hammers have been preserved. Given the regularity of the square layout, the exclusive use of channels for the extraction of blocks, and the fact that the bottom of the quarry is 1.3 m below the present-day sea level, Quarry 1 on Kamenjak can be dated to the period of Classical Antiquity.

Quarry 2 (Fig. 8) is situated approximately thirty metres west of Quarry 1. The faces are irregular, with clearly visible remains of holes made by a hand drill and cracks in the rocks which are a consequence of the use of gunpowder. Figure 8 represents the trace of a hand drill and a horizontal crack which is a con-

Sl. 9. / Fig. 9.
Kamenolom 3 na Kamenjaku (foto: M. Parica).
Quarry 3 on Kamenjak (photo by M. Parica).

Kamenolom 3 smješten je na južnoj obali otoka (Sl. 9.). Tlocrtni mu je oblik trokut s pravim kutom u središnjem dijelu. Eksploatacija je vršena isključivo tehnikom kopanja pašarina i to gotovo u cjelokupnoj visini litice. Očuvan je i ostatak pašarina pretpostavljene širine od 50 cm. Datiranje ovoga kamenoloma može se izvesti na temelju nekoliko činjenica. Tlocrtno se razlikuje od antičkih kamenoloma na otoku (kamenolomi 1 i 6). Razlikuje se i od nepravilnih novovjekovnih kamenoloma gdje su korišteni neprekidni utori za klinove "V" oblika koji se tradicijski nazivaju kunjere, te dijelovi gdje su stijene razbijane barutom. Stoga se općenito ovaj kamenolom može smjestiti između antičke i novovjekovne faze. Još točniju kronološku odrednicu moguće je potražiti prema arhivskom podatku o oltarnoj ploči i pregradi svetišta sa stupićima, stopama, glavicama i arkadicama, koju je 1404. godine isklesao Dubrovčanin Andrija Juričević na nekom „otočiću

sequence of the use of gunpowder. Waste material is scattered around the foot of the mentioned remains. Given the use of gunpowder, Quarry 2 can be dated to the modern era.

Quarry 3 is situated on the southern coast of the island (Fig. 9). The layout has a triangular form with a right angle in the central part. Exploitation was carried out solely through the technique of hammering channels, which was done almost up the entire height of the face. The remains of channels with an assumed width of 50 cm have also been preserved. The dating of the quarry is possible based on several facts. In the first place, the layout varies from that of the Classical Antiquity quarries on the island (Quarries 1 and 6). It also varies from irregular modern-era quarries, where uninterrupted grooves for V-shaped wedges were used (traditionally called *kunjera*), and there are parts where rocks were blasted with the use of gunpowder, which can

Sl. 10. / Fig. 10.
Litica kamenoloma 4 na Kamenjaku (foto: M. Parica).
Face of Quarry 4 on Kamenjak (photo by M. Parica).

kamenoloma“ kraj Molata, za crkvu sv. Augustina u Fermu.[7] Iako je otočić Kamenjak nešto bliže otoku Istu nego Molatu, vjerojatno je riječ upravo o Kamenjaku jer je Molat znatno veći otok te su se u razdoblju srednjeg vijeka referirali na njega.

Kamenolom 4 (Sl. 10.) ima gotovo iste karakteristike kao i kamenolom 3. Korišteni su pašarini rađeni lakšim dvošiljem cijelom visinom litice. Izvorni tlocrt vjerojatno je također bio u obliku istokračnog trokuta, međutim novovjekovne devastacije na istočnoj litici značajno su poremetile originalni tlocrt. Kamenolom 4 može se slobodno staviti u isti kronološki kontekst kao što je to slučaj i kod kamenoloma 3.

Kamenolom 5 (Sl. 11.) predstavlja jednu širu zonu na kojoj je očuvano mnoštvo tragova eksploatacije kamena, kao što su ostaci rupa od ručnih

generally be dated to between Classical Antiquity and the modern era. An even more precise dating can possibly be determined based on archive data concerning an altar panel and altar screen with pillars, base plates and arcades, carved in 1404 by the Dubrovnik stonemason Andrija Juričević from stone from a quarry on an islet near Molat for the Church of St. Augustus in Fermo.[7] Although the islet of Kamenjak is somewhat closer to the island of Ist than to the island of Molat, it must have been Kamenjak, as Molat is significantly larger and was referred to in the Middle Ages.

Quarry 4 (Fig. 10) has almost the same characteristics as Quarry 3. The channels were hammered out with a lighter two-spiked hammer along the entire height of the face. The original layout probably also had the form of an isosceles triangle, although

7 C. FISKOVIĆ, 1959, 32.

7 C. FISKOVIĆ, 1959, 32.

Sl. 11. / Fig. 11.
Područje kamenoloma 5 na Kamenjaku (foto: D. Vujević).
Area of Quarry 5 on Kamenjak (photo by D. Vujević).

svrdala, izlomljene stijene od eksplozija baruta, horizontalne i vertikalne kunjere te ostaci pojedinačnih utora za klinove. Zona kamenoloma 5 može se okvirno datirati u novovjekovno razdoblje, posebice zbog korištenja baruta. Kunjere i utori za metalne klinove korišteni su istodobno s uporabom baruta. Na periferiji zone kamenoloma 5, na prirodnoj litici koja ne sadrži nikakve tragove alata, nalaze se uklesana glava u reljefu (Sl. 12.) i tri križa. Glava se nalazi na oko četiri metra visine od tla. Uz križ najbliži glavi uklesana su slova "S C".

Kamenolom 6 (Sl. 13.) smješten je na sjeveroistočnom kutu Kamenjaka. Riječ je o pravokutnoj penetraciji u otok dužine 13 m, a širine 6 m. Litice kamenoloma su okomite i pravilne, no poprilično oštećene djelovanjem mora. Zbog istog razloga vrlo se teško zamjećuju mjestimično očuvani tragovi alata od izrade pašarina. Dno kamenoloma ispunjeno je naslagama urušenog kamena. Matična stijena na dnu kamenoloma znatno je ispod

modern-era devastation on the eastern face has significantly disturbed the original layout. Quarry 4 can with a high degree of certainty be set in the same chronological context as Quarry 3.

Quarry 5 (Fig. 11) represents a broader zone in which numerous traces of stone exploitation have been preserved, such as the remains of holes from hand drills, rocks blasted by gunpowder, horizontal and vertical cracks (*kunjera*), and the remains of individual slots for inserting wedges. The Quarry 5 area can be dated approximately to the modern era, particularly based on the use of gunpowder. The cracks (*kunjera*) and slots for inserting metal wedges were used simultaneously with gunpowder. On the periphery of Quarry 5, on a natural face which contains no tool traces, the relief of a head (Fig. 12) and three crosses have been engraved. The head is placed approximately four metres above the ground. Next to the cross that is closest to the head, the letters "S C" have been engraved.

Sl. 12. / Fig. 12.
Uklesana glava i jedan od tri križa na litici Kamenjaka (foto: D. Vujević).
Engraved head and one of the three crosses on the Kamenjak face (photo by D. Vujević).

Sl. 13. / Fig. 13.
Litica kamenoloma 6 na Kamenjaku (foto: M. Parica).
Face of Quarry 6 on Kamenjak (photo by M. Parica).

morske razine, no same naslage urušenog kamena onemogućuju točan uvid. Kamenolom 6 tlocrtom, razinom ispod morske površine te tragovima alata, evidentno podsjeća na kamenolom 1. S obzirom na navedene činjenice, kamenolom 6 može se datirati u antičko razdoblje.

POPOVIĆI – OTAVAC

Kamenolom se nalazi neposredno ispod vrha brda Otavac (Sl. 14.) koji se uzdiže nad selom Popovići, pet kilometara sjeveroistočno od grada Benkovca. Litica kamenoloma proteže se u dužini od gotovo 70 m, dok joj je najveća visina oko 8 m. Površinski sloj, debljine od 3 do 4 m, pokazuje pločasto uslojenje karakteristično za benkovačko područje, dok se ispod nalazi vapnenački depozit arhitektonskog kamena. Vapnenac je svijetložute nijanse te sitnozrnate strukture koja podsjeća na pješčenjak. Tragovi alata vidljivi su na svim okomitim liticama kamenoloma (Sl. 15.). Jasno se ocrtavaju strije od dubokih pašarina koje su posljedica rada s teškim dvošiljem.

Quarry 6 (Fig. 13) is situated in the north-eastern corner of Kamenjak. It represents a rectangular protrusion into the island 13 m in length and 6 m in width. The quarry's faces are vertical and regular. However, they have been damaged as a result of the activity of the sea. For the same reason, traces of the tools for creating channels, which have been partly preserved, are hardly visible. The bottom of the quarry is filled with the deposits of broken stone. The bedrock at the bottom of the quarry is far below sea level, and the layers of broken stone deposits make a precise overview impossible. The layout, its being below sea level, and the tool traces in Quarry 6 are clearly reminiscent of Quarry 1. Given all of the above, Quarry 6 can be dated to the Classical Antiquity period.

POPOVIĆI – OTAVAC

The quarry is situated directly below Otavac Hill (Fig. 14), which rises above the village of Popovići, five kilometres north-east of the town of Benkovac.

Sl. 14. / Fig. 14.
Litica kamenoloma na brdu Otavac neposredno ispod srednjovjekovne kule (foto: M. Parica).
Quarry face directly beneath a mediaeval tower on Otavac hill (photo by M. Parica).

Sl. 15. / Fig. 15.
Litica kamenoloma Otavac s vidljivim tragovima alata (foto: M. Parica).
Quarry face with visible tool traces (Otavac) (photo by M. Parica).

S južne strane litice kamenoloma, na pojasu dvadesetak metara udaljenom od litice, nalaze se gomile otpadnog kamenja koje sadržavaju karakteristične sitnije pločaste ulomke, kao posljedicu kopanja pašarina. Gomile su na nekim mjestima pomiješane s erodiranom zemljom te se jedva zamjećuju. Po vrhu otpadnih gomila zamjećuju se temelji od različitih objekata čiji smještaj govori da su sagrađeni nakon najintenzivnijeg korištenja kamenoloma te su najvjerojatnije u vezi s kulom koja se uzdiže nad kamenolomom.

S obzirom na veličinu zahvata u stijenskoj masi, zatim na kasnosrednjovjekovne strukture koje su izgrađene po otpadnim gomilama, tragove alata i tehnike eksploatacije unutar samo jedne faze, kamenolom u Popovićima može se s određenom dozom vjerojatnosti datirati u period rimske uprave, a time ujedno i povezati s većim potrebama za arhitektonskim kamenom antičke Aserije.

DUGI OTOK – OVČA

Uvala Ovča smještena je na približno dva kilometra južno od mjesta Savar, na središnjem dijelu Dugog otoka. Brusić spominje kamenolome kod mjesta Savar i ističe kako se rimski iskopi nalaze podalje od morske obale (možda zbog bolje kvalitete kamena, ili manjeg utjecaja soli na njega).[8] U okolici same uvale vidljiva su četiri kamenoloma.

Najveći je kamenolom 1 (Sl. 16.). Smješten je na nadmorskoj visini od 60 do 80 m, jugozapadno od

8 Z. BRUSIĆ, 1974, 68.

The face of the quarry stretches almost 70 m, while its greatest height is approximately 8 m. The surface layer, between 3 and 4 m thick, has panel-shaped layers characteristic of the Benkovac area, while below there is a limestone deposit of architectural stone. The limestone is of a light yellow shade with a small-grain structure reminiscent of sandstone.Tool traces are visible on all the vertical faces of the quarry (Fig. 15). Striae from deep channels are clearly visible and are a consequence of work with a heavy two-spiked hammer.

On the southern side of the face, in a belt stretching along an area approximately twenty metres from the face, there are deposits of waste stone containing typical smaller panel-shaped fragments resulting from hammering the channel. The deposits are partially mixed with eroded earth, and as such are barely discernible. On the top of the waste heaps, the foundations of different structures are visible, the positions of which suggest that they were built after the most intensive use of the quarry and are most probably linked with the tower above the quarry.

Given the size of the interventions in the rock mass, the late mediaeval structures built on the waste deposits, the tool traces, and the exploitation technique being used in only one phase, the quarry in Popovići can quite probably be dated to the period of Roman rule and can be associated with the growing demand for architectural stone in classical antique *Asseria*.

DUGI OTOK – OVČA

Ovča Bay is situated approximately two kilometres south of Savar in the central part of Dugi Otok. Z. Brusić mentions quarries near Savar and points out that the Roman digs are quite far from the shore (possibly due to better stone quality or salt having less effect).[8] In the surroundings of the bay, four quarries are visible.

Quarry 1 (Fig. 16) is the largest. It is situated 60 to 80 m above sea level, south-west of the most sheltered part of Ovča Bay. It has an artificially created face whose base is approximately 20 to 25 m wide, with a greatest height of 10 m. On the faces of this quarry, there is evidence of almost all stone-extracting techniques. The largest part suggests the blasting of stone with explosive powder. This modern-era technique was used to exploit almost

8 Z. BRUSIĆ, 1974, 68.

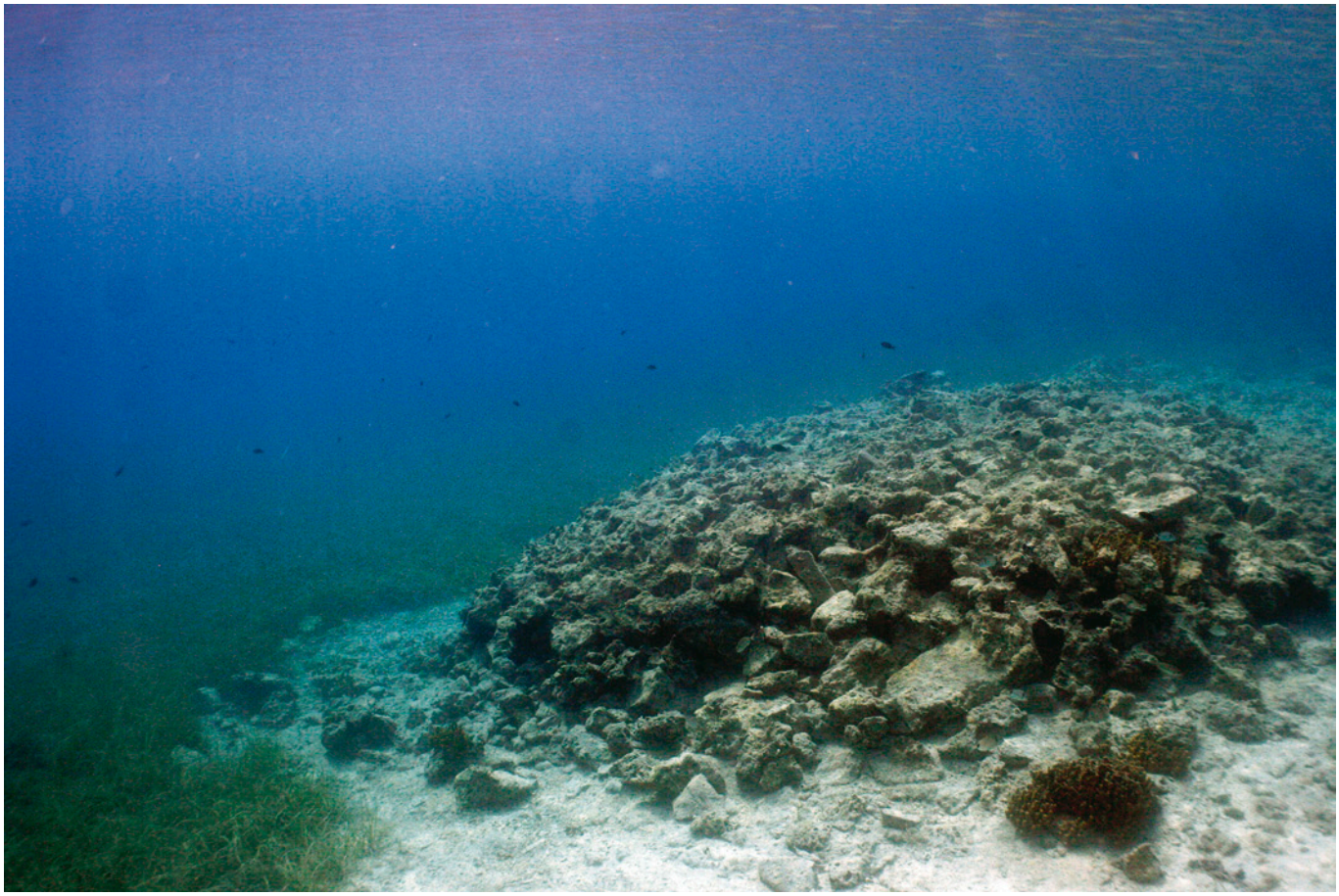
Sl. 16. / Fig. 16.
Pogled na veći kamenolom u uvali Ovča (foto: M. Parica).
View of a larger quarry in Ovča Bay (photo by M. Parica).

najzaklonjenijeg dijela uvale Ovča. Riječ je o umjetno stvorenim liticama koje su u svojem baznom dijelu široke oko 20 do 25 m, dok je najveća visina do 10 m. Na liticama ovoga kamenoloma susrećemo tragove gotovo svih tehnika vađenja kamena. Najvećim dijelom vidljivo je odvajanje kamena barutom. Ovom novovjekovnom tehnikom eksploatiran je gotovo čitav kamenolom što nam uvelike otežava uvid u starije tehnike na istom nalazištu. Unutar istoga kamenoloma, pri vrhu manje izdignute stijene, vidi se pašarin u kutu manjeg, pravilno iskopanog prostora. Čišćenjem od raslinja otkriven je ostatak jednog pašarina na okomitoj stijeni, na kojoj se jasno vide tragovi čekića dvošilja (Sl. 17.). Ovo govori u prilog mišljenju kako ovaj mali sačuvani dio pripada antičkom kamenolomu. Kolike su bile njegove dimenzije, nemoguće je utvrditi bez arheoloških iskopavanja. Evidentno je kako je novovjekovni kamenolom gotovo u potpunosti devastirao antički kamenolom. U prilog antičkoj dataciji ovoga dijela ide i tanak sloj iz kojeg vire ulomci antičkih amfora. Sloj se nalazi neposredno iznad žive stijene pokraj

the entire quarry, which makes it much harder to understand the older techniques at the same site. Within the same quarry, near the top of a less elevated rock, a channel is visible in the corner of a small, regularly hammered area. Upon removing the vegetation, the remains of a channel on a vertical rock were uncovered, where traces of a two-spiked hammer (Fig. 17) are clearly visible. This suggests that this small preserved part belongs to the classical antique quarry. However, its dimensions cannot be determined without an archaeological campaign. Clearly, the modern-era quarry almost entirely devastated the antique one. In support of dating this part to the Classical Antiquity period, there is also a thin layer from which fragments of classical antique amphorae stand out. The layer is situated directly above the bedrock, next to which there is the channel. This is actually the bottom of the dig of the classical antique quarry (Fig. 18). At the bottom, there were fragments of amphorae, and later everything was covered with waste. In the sea in Ovča Bay, at a depth of two metres, there is a 12-m-long sunken

Sl. 17. / Fig. 17.
Vidljivi tragovi alata unutar pašarina (foto: M. Parica).
Visible tool traces within the channel (photo by M. Parica).

Sl. 18. / Fig. 18.
Označeni sloj u kojem se javljaju fragmenti antičkih amfora (foto: M. Parica).
Marked layer with fragments of classical antique amphorae (photo by M. Parica).



Sl. 19. / Fig. 19.
Ostatak antičkog gata u uvali Ovča (foto: M. Parica).
Remains of a classical antique mole in Ovča Bay (photo by M. Parica).

koje je pašarin, a to je zapravo dno iskopa antičkoga kamenoloma (Sl. 18.). Na spomenutom su dnu bili fragmenti amfora, a sve je to skupa kasnije zasuto otpadom. Unutar uvale Ovča, u moru, na dva metra dubine, nalazi se potopljeni gat duljine 12 m (Sl. 19.).[9] Nivo samog gata niži je za dva metra od današnje razine mora. Ulomci amfora, dolija i ostali ulomci antičke keramike okvirno datiraju ovu konstrukciju u antičko razdoblje.

Kamenolom 3 (Sl. 20.) smješten je više stotina metara sjeveroistočno od kamenoloma 1, na poziciji uz prirodnu dragu koja se naziva Rovine. Litice kamenoloma su nepravilnih oblika. Jedine pravilnije plohe nalaze se na kutu eksploatacijske zone. To je najdublji dio kamenoloma i jedino su na njemu vidljivi tragovi alata od kopanja pašarina te određena pravilnost u iskopu. Tlocrt kamenoloma je trokutastog oblika, a tragovi strija govore o korištenju lakših dvošilja. Važan nam je i arhivski podatak o

9 Lučka instalacija detaljnije obrađena u M. PARICA, 2012.

mole (Fig. 19).[9] The mole is two metres below the present-day sea level. Fragments of amphorae, dolia, and other classical antique pottery shards date this construction approximately to the Classical Antiquity period.

Quarry 3 (Fig. 20) is situated several hundred metres north-east of Quarry 1, and is located near a natural cove called Rovine. The faces have irregular forms. The only regular surface is that in the corner of the exploitation zone. This is the deepest part of the quarry, and the only spot with visible traces of tools for hammering channels and where there is certain regularity to the digging. The quarry's layout has a triangular form, while the traces of striae suggest the use of light two-spiked hammers. Archive data on how Mihajlo Ladislav produced five Gothic windows for Petar a Criminalibus in 1468 are also important. Two of these were decorated with a coat of arms and surrounded with teeth, while three were

9 The harbour installation was discussed in detail in M. PARICA, 2012.

Sl. 20. / Fig. 20.
Najstariji dio kamenoloma 3 u uvali Ovča (foto: M. Parica).
The oldest part of Quarry 3 in Ovča Bay (photo by M. Parica).

tome kako je Mihajlo Ladislav izradio Petru a Criminalibus 1468. godine pet gotičkih prozora, od kojih su dva bila iskićena grbom i okružena zupcima, a tri jednostavna, od kamena uzetog u kamenolomu „sred drage“ Ovče na Dugom otoku.[10] Ovo preciziranje „sred drage” je vrlo važno jer se smještajem radi najvjerojatnije baš o ovom kamenolomu u blizini same drage, dok su ostali kamenolomi u uvali Ovča uz more ili na brijegu. Stoga kasnosrednjovjekovnu dataciju možemo pripisati upravo ovom kamenolomu.

Po svemu navedenom, kamenarska aktivnost u okolici uvale Ovča započinje u antici te zajedno s obližnjim antičkim kamenolomima Padrare čini jedan kompleks, dok se kasnije obnavlja u kasnom srednjem vijeku. U novom vijeku došlo je do devastacije najvećega kamenoloma u uvali Ovča.

simpler, made of stone extracted from the *Sred Drage* [centre of the cove] of Ovče quarry on Dugi Otok.[10] Specifying the central position (*Sred Drage*) is of particular importance, because most probably it was the quarry situated in the vicinity of the cove, while the other quarries in Ovča Bay are either along the sea or on the hill, which means that a late mediaeval dating can be ascribed to this particular quarry.

Thus, quarrying in the surroundings of Ovča Bay started in Classical Antiquity. It was part of a complex, together with the nearby classical antique Padrare quarries, and restored in the Late Middle Ages. In the modern era, the largest quarry in Ovča Bay was devastated.

10 C. FISKOVIĆ, 1959, 60.

10 C. FISKOVIĆ, 1959, 60.

Sl. 21. / Fig. 21.
Satelitska snimka prostora Suve lokve kod Žaborića (izvor: Arkod).
Satellite image of the area of Suva Lokva near Žaborić (source: Arkod).

ŽABORIĆ – SUVA LOKVA

Kamenolom Suva lokva smjestio se dva kilometra istočno od uvale Studena u mjestu Žaborić, na 60 m nadmorske visine (Sl. 21. i 22.). Litice kamenoloma dosežu do 12 m visine.

Tehnika eksploatacije ostavila je mnogobrojne tragove na liticama kamenoloma. Jasno su vidljive strije od pašarina koje su posljedica korištenja lakših dvošilja, a na više mjesta vidljive su i kunjere "V" oblika. Kamenolom je u potpunosti iskorišten tehnikom kopanja pašarina. Nisu primjetne pravilnosti u iskopu kakve nalazimo kod antičkih kamenoloma. Primjetno je postupno širenje cjelokupnoga kamenoloma od središnjeg dijela prema zapadu, jugu i istoku. Otpadne gomile su sačuvane, a kameni fra-

ŽABORIĆ – SUVA LOKVA

Suva Lokva quarry is situated two kilometres east of Studena Bay in Žaborić at an altitude of 60 m above sea level (Figs. 21, 22). The faces of the quarry reach a height of up to 12 m.

The exploitation technique has left numerous traces on the faces. The striae from the channels made by light two-spiked hammers, and in several places also V-shaped grooves, are clearly visible. The quarry was entirely exploited using the technique of hammering channels. There are no noticeable regularities in the extrusions as in classical antique quarries. A gradual expansion of the entire quarry from the central part towards the west, south and east is noticeable. Waste heaps have been preserved, and

Sl. 22. / Fig. 22.
Kamenolom Suva lokva kod Žaborića (foto: M. Parica).
Suva Lokva quarry near Žaborić (photo by M. Parica).

gmenti u otpadu dokazuju kako je gotovo cijeli prostor kamenoloma eksploatiran ručnim alatima uz pomoć pašarina.

Određene specifične pojave mogu poslužiti u kronološkoj determinaciji nalazišta. Nedostatak pravilne organizacije iskopa, korištenje lakših dvošilja pri izradi pašarina te nepravilne litice kamenoloma nikako ne idu u prilog datiranju u antički period. Srednjovjekovna i možda ranonovovjekovna epoha ostaju kao najvjerojatnije vrijeme nastanka spomenutoga kamenoloma.

stone fragments in the waste confirm that almost the entire area of the quarry was exploited by hand tools, with the help of channels.

Certain specific phenomena can serve to chronologically determine the site. The lack of regular organisation in the quarrying, the use of light two-spiked hammers for making the channels, and the irregular faces of the quarry do not support dating it to the Classical Antiquity period. The Middle Ages and possibly the early modern era remain the most probable periods for the formation of the quarry.

Sl. 23. / Fig. 23.
Satelitska snimka prostora Sv. Ilije s naznačenim nalazištima (izvor: Arkod).
Satellite image of the Sveti Ilija area with marked sites (source: Arkod).

TROGIR – SV. ILIJA

U neposrednoj blizini grada Trogira, na istočnim padinama brda Sv. Ilija, nalazi se kompleks od više kamenoloma koji pripadaju gotovo svim povijesnim razdobljima (Sl. 23.). Na satelitskoj snimci kompleks je označen s pet glavnih pozicija, no čitav prostor sadržava ostatke eksploatacije vrlo kvalitetnoga arhitektonskog vapnenca. Neki dijelovi kompleksa kamenoloma Sv. Ilija trajno su izgubljeni recentnom eksploatacijom. Nažalost, i u novije vrijeme dodijeljene su nove koncesije za daljnje uništavanje ove kulturne baštine.

Kamenolom 1, u literaturi je poznat pod imenom Kučićeva kava (Sl. 23/1.). Riječ je o otvorenom kopu koji je dosegnuo najdublje slojeve u odnosu na ostale kamenolome kompleksa Sv. Ilija. Iako je doživio

TROGIR – SVETI ILIJA

In the direct vicinity of the town of Trogir, on the eastern slopes of the hill of Sveti Ilija, there is a complex of several quarries encompassing nearly all historical periods (Fig. 23). On the satellite image, the complex is marked with five main positions. The entire area contains the remains of the exploitation of architectural limestone of very high quality. Some parts of the complex of the Sveti Ilija quarry have been permanently lost during recent exploitation, and unfortunately new concessions have recently been granted for further destruction of this cultural heritage.

Quarry 1 is known in the literature by the name of Kučićeva Kava (Fig. 23/1). This is an open excavation which has reached the deepest layers compared to other quarries of the Sveti Ilija complex.

Sl. 24. / Fig. 24.
Fotografija Kučićeve kave s označenim fazama eksploatacije (foto: M. Parica).
Photo of Kučićeva Kava with marked exploitation stage (photo by M. Parica).

recentne devastacije, u unutrašnjosti se jasno vide tragovi pašarina izrađeni težim dvošiljem te pojedini segmenti kamenoloma s pravokutnim tlocrtom. Litice kamenoloma uzdižu se i do 20 m visine. Očuvana je i izvorna komunikacija koja spaja unutrašnjost kamenoloma s pretpostavljenom komunikacijom prema podnožju brda, a na stjenkama se jasno razaznaju strije od korištenja teškog dvošilja pri izradi prosjeka kroz živu stijenu. Izvorna faza antičkoga kamenoloma, na temelju arheoloških nalaza koje objavljuje D. Maršić, može se datirati u 1. stoljeće poslije Krista.[11]

Osim dijelova kamenoloma koji nedvojbeno pripadaju antičkom razdoblju, sjeverozapadne litice kamenoloma pokazuju tragove naknadne eksplo-

Although it has undergone recent devastation, traces of channels made with a heavier two-spiked hammer and individual segments of a quarry with a rectangular layout are clearly visible. The faces of the quarry reach a height of up to 20 m. The original communication route connecting the quarry's interior with the presumed communication route towards the foot of the hill has been preserved. On the walls, striae from a hard two-spiked hammer used to make a cut in the bedrock are clearly discernible. Based on archaeological finds published by D. Maršić, the original phase of the classical antique quarry can be dated to the first century AD.[11]

Apart from parts of the quarry that undoubtedly belong to the Classical Antiquity period, the north-

11 D. MARŠIĆ, 2007, 111.

11 D. MARŠIĆ, 2007, 111.

atacije u kasnijim fazama korištenja kamenoloma. Na sl. 24. vide se označene faze kamenoloma, od najstarije prema najnovijoj. Prva faza predstavlja izvorni antički kamenolom s pravokutnim tlocrtom, dubokog otvorenog kopa, koji s izlaznim hodnikom čini cjelinu.

Druga faza eksploatacije vidljiva je na stepenastim segmentima koji se uzdižu sjeverozapadno od antičkog dijela kamenoloma. Očigledno se u određenom razdoblju nakon klasičnoga rimskodobnog razdoblja nastavila eksploatacija u smjeru od izvorne litice antičkoga kamenoloma, prema vrhu brda. Tragovi alata na liticama kamenoloma druge faze predstavljaju lakše dvošilje, a otpad spomenute faze eksploatacije zapunio je izvorni antički kamenolom.

Treća faza predstavlja tragove novovjekovnih metoda kao što su: tragovi korištenja ručnih svrdala i baruta, horizontalne kunjere te pojedinačni utori za klinove.

KORČULA – VRNIK

Otok Vrnik na svojem sjeveroistočnom dijelu sadrži veći broj kamenoloma (Sl. 25. i 26.). Riječ je o pravokutnim otvorenim kopovima koji u tlocrtu mogu biti dimenzija i do 30 x 30 m, dok visina umjetno stvorenih litica može prelaziti i više od 40 m.

Ostali su sačuvani kamenolomi koji su najudaljeniji od mora, no u početnim fazama eksploatacije Vrnika kamenolomi su se nalazili bliže obali, a kako su otvarani novi, zona eksploatacije se pomicala prema vrhu otoka. Ovaj proces je konstantno uništavao kamenolome bliže obali. Novi kamenolomi nastavljaju eksploataciju od litica ranijih, a s druge strane, velika količina otpadnog kamena deponira se na prostor starijih kopova. Jedino što ostaje na istom mjestu je komunikacija za izvoz kamenih blokova prema moru.

U zoni ranijih kamenoloma na nekoliko pozicija vidljivi su manji segmenti stijenske mase koji sadrže tragove alata. Ovo su ostaci nekadašnjih otvorenih kopova većinom iskorištenih do morske razine te kasnije zatrpanih otpadnim kamenjem.

Najstariji kamenolomi na Vrniku su galerijski kamenolomi koje spominje M. Gjivoje,[12] a koji su u većini slučajeva preslojeni novim kamenolomima koji se okvirno mogu datirati u kasnosrednjovjekovno i novovjekovno razdoblje. Zanimljiv je i podatak kako je kamenolom Soline na otoku Korčuli u

12 M. GJIVOJE, 1970, 72.

western faces demonstrate traces of exploitation during later phases. In Figure 24, the marked phases of the quarry are visible, from the oldest to the most recent. The first stage represents the original antique quarry with a rectangular layout, a deep open quarrying and an exit hall, which are all part of the same complex.

The second exploitation stage is visible in stair-shaped segments stretching upwards north-west of the classical antique part of the quarry. Obviously, at a certain point after the Roman period, exploitation continued from the original face of the classical antique quarry towards the top of the hill. Tool traces on the faces of the second phase quarry are present in the shape of those from light two-spiked hammers, and the waste from this exploitation phase filled the original antique quarry.

The third stage represents traces of modern era methods, such as the use of hand drills and gunpowder, horizontal grooves (*kunjera*), and individual grooves for wedges.

KORČULA – VRNIK

The island of Vrnik has a large number of quarries in its north-eastern part (Figs. 25, 26). These are rectangular open digs with layouts reaching up to 30 x 30 m, while the height of the artificially created faces can exceed 40 m.

The quarries that have been preserved are those that are the furthest from the sea. In the initial stage of Vrnik's exploitation, the quarries were closer to the coast, but as new ones were opened, the exploitation zone shifted towards the top of the island. The process destroyed the quarries closer to the coastline. The new quarries continued exploitation from the faces of earlier quarries. On the other hand, a great quantity of waste stone was deposited in the areas of older digs. The only thing that remains in the same place is the communication route for transporting stone blocks towards the sea.

In the area of earlier quarries, in several places smaller segments of rock mass are visible which contain tool traces. These are the remains of the former open digs which were mostly used at sea level and later filled with waste stone.

The oldest quarries at Vrnik are the gallery quarries mentioned by M. Gjivoje,[12] which in most cases were overlaid with new quarries that can approximately be dated to the late mediaeval and modern

12 M. GJIVOJE, 1970, 72.

Sl. 25. / Fig. 25.
Satelitska snimka otoka Vrnika s označenim najvažnijim kamenolomima (izvor: Arkod).
Satellite image of the island of Vrnik with the most important quarries marked (source: Arkod).

Sl. 26. / Fig. 26.
Kamenolom u zoni 3 na Vrniku (foto: M. Parica).
Quarry in zone 3 on Vrnik (photo by M. Parica).

15. stoljeću već bio iscrpljen, zbog čega su se morali otvarati novi kamenolomi na otocima Vrniku i Kamenjaku.[13] Kako početak masovnije eksploatacije na Vrniku započinje u 15. stoljeću, stariji kamenolomi preslojeni su otpadom novijih, koji se pomiču uvijek za jednu liniju više prema vrhu otoka.

Na svim kamenolomima otvorenog tipa na Vrniku razabire se korištenje lakših dvošilja za izradu pašarina, a vremenski okvir vrničkih kamenoloma obuhvaća kraj srednjeg vijeka te gotovo cijeli novi vijek.

* * *

Uzimajući u obzir broj strija po dužnom metru te datacije opisanih kamenoloma, vrijednosti je moguće uvrstiti u grafikon. Rezultat upućuje na jasnu razliku u broju strija između antičkih i srednjovjekovnih kamenoloma (Sl. 27.).

Na temelju nekoliko prethodno opisanih kamenoloma koji sadrže elemente za pouzdanu dataciju, mogu se primijetiti određene zakonitosti na temelju tragova alata koji se razaznaju na liticama kamenoloma. Strije od pašarina pokazuju kako antička faza opisanih kamenoloma pokazuje određene specifičnosti. Prije svega evidentno je da kad

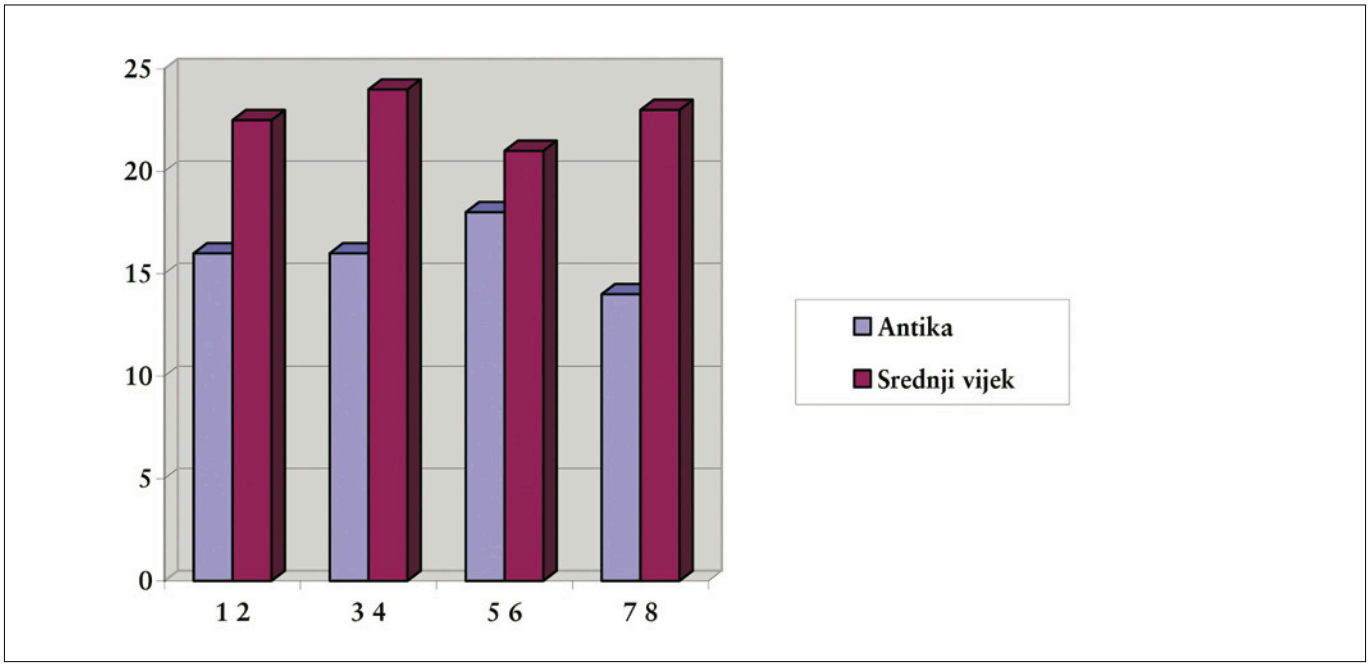
era periods. It is interesting that the Soline quarry on the island of Korčula was already exhausted in the 15th century. For this reason, new quarries had to be opened up on the islands of Vrnik and Kamenjak.[13] As the beginning of mass exploitation at Vrnik started in the 15th century, older quarries were covered with waste from more recent ones, which always move one at a time towards the top of the island.

In all the open-type quarries at Vrnik, the use of light two-spiked hammers for the construction of the channels is discernible, and consequently the Vrnik quarries can be dated towards the end of the Middle Ages and almost the entire modern era.

* * *

Taking into consideration the number of striae per metre and the dating of the above quarries, it is possible to represent the values in a chart. The results suggest a clear difference in the number of striae in the classical antique and in the mediaeval quarries (Fig. 27).

On the basis of several previously described quarries containing elements that can be reliably dated, certain regularities can be noticed based on the tool traces discernible on the faces. The striae



Sl. 27. / Fig. 27.

Grafikon s vrijednostima broja tragova strija po dužnom metru s označenim nalazištima: 1 – Sv. Ilija (Trogir), 2 – Sv. Ilija (Trogir), 3 – Popovići (Benkovac), 4 – Kamenjak 3 (Ist), 5 – Kamenjak 1 (Ist), 6 – Suva Lokva (Žaborić), 7 – Ovča (Dugi otok), 8 – Vrnik (Korčula).

Graph showing the numbers of striae traces per metre with sites marked: 1 – Sveti Ilija (Trogir), 2 – Sveti Ilija (Trogir), 3 – Popovići (Benkovac), 4 – Kamenjak 3 (Ist), 5 – Kamenjak 1 (Ist), 6 – Suva Lokva (Žaborić), 7 – Ovča (Dugi Otok), 8 – Vrnik (Korčula).

13 C. FISKOVIĆ, 1955, 20.

13 C. FISKOVIĆ, 1955, 20.

Sl. 28. / Fig. 28.
Reljef s prikazom kamenara iz Pule (preuzeto iz A. STARAC, 2006, 42).
Relief with the representation of a stonemason from Pula (from: A. STARAC, 2006, 42).

Sl. 29. / Fig. 29.
Antički dvošilj (British Museum, foto: M. Parica).
Antique two-spiked hammer (British Museum, photo: M. Parica).

se koristi teški dvošilj za kopanje pašarina, visina pojedinačnog otkopa koji pokazuju tragovi alata je veća te strije često pokazuju zakrivljenost.

S druge strane, kasnosrednjovjekovni i ranonovovjekovni tragovi alata pokazuju sasvim drugačije karakteristike. Strije su gušće što je posljedica rada s manjim dvošiljem, visina pojedinačnog otkopa je manja, a strije su pravilnije, poput uzorka riblje kosti. Ukupna dubina pašarina izrađenih manjim dvošiljima može biti veća zbog lakšeg rada s manjim alatima u ograničenom prostoru. U izvanrednim okolnostima, ako je bila potrebna ekstrakcija većega kamenog bloka, moguće je da se, na teško dostupnim mjestima, rabio samo čekić i špica.

Tragovi alata na liticama kamenoloma evidentno dokazuju jasnu razliku između antike i srednjeg vijeka i to u vidu smanjene težine dvošilja, osnovnog kamenarskog alata. Spomenuta promjena vidljiva je na liticama kamenoloma. Antički dvošilj (Sl. 28. i 29.) je teži, od šest do osam kilograma te ostavlja između 15 i 19 strija na dužnom metru. Srednjovjekovni dvošilj je manje težine, od dva do četiri kilograma te ostavlja između 20 i 26 strija po dužnom metru.

from the channels demonstrate how the classical antique stage of the quarries demonstrates certain specific traits. In the first place, a heavy two-spiked hammer was clearly used to dig the channels, the height of the individual digs suggested by the tool traces is greater, and the striae are often curved.

On the other hand, late mediaeval and early mediaeval tool traces demonstrate entirely different characteristics. The striae are denser as a consequence of working with a smaller two-spiked hammer, the height of the individual dig is rather small, and the striae are regular, such as a fishbone pattern. The total depth of the channels made with a small two-spiked hammer might be larger due to the fact that it is easier to work with smaller tools in a restricted area. Under extraordinary circumstances, if the extraction of a larger stone block was necessary, it is possible that at barely accessible places only a hammer and point were used.

Tool traces on the faces clearly confirm a distinction between Classical Antiquity and the Middle Ages in the form of a reduced heavy two-spiked hammer as the basic quarrying tool. This change is visible on the very faces. The antique two-spiked hammer (Figs. 28, 29) is heavier at 6-8 kilogrammes, and leaves between 15 and 19 striae per metre. The mediaeval two-spiked hammer is lighter at 2-4 kilogrammes, and leaves between 20 and 26 striae per metre.

Sl. 30. / Fig. 30.
Posljednji klesar s Vrnika s dvošiljem u ruci (preuzeto iz M. BOŠNJAK, 2004).
The last stonecutter from Vrnik with a two-spiked hammer in his hand (from: M. BOŠNJAK, 2004).

Dvošilj, koji se još naziva dvorog ili dvokoničar, sastoji se od željezne glave koja završava na obje strane piramidalnim šiljkom čiji kutovi ovise o tvrdoći kamena za obradu. Težina tradicijskog dvošilja (Sl. 30.) varira od dva do pet kilograma.[14] Ovakvim željeznim dvošiljima koji su imali drveni držak dužine od 50 do 60 centimetara, služili su se Grci te kasnije i Rimljani u antičkom razdoblju.[15] Željezni kamenarski alat morao se stalno oštriti i popravljati te je čest slučaj da se u sklopu antičkih kamenoloma nalaze kovačke radionice,[16] a veću količinu željezne troske koju nalazimo u podnožju kamenoloma Padrare na Dugom otoku možemo pripisati jednoj takvoj radionici. Osim navedenih postoje i dvošilji s promjenjivim čeličnim šiljcima koji se uglavljuju u krajeve željezne glave, tako da se ne oštećuje glava dvošilja.[17] Sustav s promjenjivim šiljcima vjerojatno ulazi u upotrebu tek u srednjem vijeku kada dolazi do šire uporabe čelika. U tradicionalnom govoru na prostoru Dalmacije dvošilj se naziva još i *pikun* ili *piket*.

Promjena u težini alata vjerojatno je nastupila u turbulentnom razdoblju ranoga srednjeg vijeka, no nedostatak pisanih podataka te manji obim egzaktnih arheoloških ostataka kamenarstva iz spomenutog razdoblja ne dopuštaju preciznije razgraničenje. Smanjivanje alata posljedica je različitog profila radnika koji obavljaju najteže poslove ekstrakcije blokova u kamenolomu. U antičkom razdoblju spomenute poslove obavljaju robovi, osuđenici i ratni

The two-spiked hammer, also called a two-horned or a double-cone hammer, consists of an iron head which on both sides ends in a pyramidal spike whose corners depend on the hardness of the stone to be worked. The weight of traditional two-spiked hammer (Fig. 30) varies between 2 and 5 kilogrammes.[14] Such iron two-spiked hammers with a 50- to 60-centimetre-long wooden grip were used by the Greeks and later by the Romans in the Classical Antiquity period.[15] Iron quarry tools had to be constantly sharpened and repaired, and smiths' workshops were frequently a feature of Classical Antiquity quarries.[16] The large quantity of iron slag found at the foot of the Padrare quarry on Dugi Otok can be assigned to such a workshop. Apart from the previously mentioned two-spiked hammers, there are also those with changeable steel spikes fixed to the ends of the iron head to avoid damaging the head of the two-spiked hammer.[17] The system with changeable spikes probably started to be used as late as in the Middle Ages, when steel became more widely used.

This change in the weight of the tools probably occurred in the turbulent Early Middle Ages period. However, the lack of written sources, and a smaller amount of archaeological quarry remains from the period allow no precise dating. The reduction in the size of tools was a consequence of the different profiles of the workers who conducted the hardest work of extracting the blocks in a quarry. In the Classical Antiquity period, the work was done by slaves, convicts, and prisoners of war, who after long periods of work with a two-spiked hammer weighing more than six kilogrammes would

14 N. DŽAJA, 1999, 39.
15 J. C. BESSAC, 1988, 42.
16 E. CHIOTIS, G. PAPADIMITROU, 1995, 8.
17 N. DŽAJA, 1999, 40.

14 N. DŽAJA, 1999, 39.
15 J. C. BESSAC, 1988, 42.
16 E. CHIOTIS, G. PAPADIMITROU, 1995, 8.
17 N. DŽAJA, 1999, 40.

zarobljenici, koji zasigurno nakon dugotrajnog rada s dvošiljem, teškim i više od šest kilograma, imaju značajne zdravstvene posljedice. U srednjem vijeku iste ove poslove rade obrtnici – kamenari, nadničari i majstorski šegrti čija ugovorena praksa traje i do osam godina, te je smanjivanje težine alata prilagođeno zahtjevima tadašnjih kamenara. Pašarin je najpogodniji sustav vađenja kvalitetnoga arhitektonskog kamena i u razdoblju novog vijeka, no nema promjena u težini alata i sustavu eksploatacije u odnosu na srednji vijek. Jedino je primjetna pojava baruta, ručnih bušotina, željeznih klinova i sl. Ove nove tehnike smanjuju iskoristivost sirovine i koriste se paralelno s klasičnom tehnikom, a rijetko se kombiniraju. Katkad se barut rabi za razbijanje gornjeg sloja nekvalitetnoga kamena, dok se ispod toga nastavlja eksploatacija isključivo ručnim alatima.

Tlocrti obrađenih kamenoloma pokazuju još jednu evidentnu razliku. Antički kamenolomi imaju pravokutni tlocrt najbolje vidljiv u slučaju Kučićeve kave, antičkih kamenoloma na Kamenjaku kod otoka Ista te u kamenolomu na položaju Padrare na Dugom otoku. Ovakav tlocrt posljedica je sustavne eksploatacije koja zauzima određene pravilne gabarite prostora gdje se vadi kamen. U sljedećoj fazi, na mjestu najkvalitetnije stijenske mase opet se vrši penetracija u novi dio otvorenoga kopa koji također ima pravokutan tlocrt. Osim sustava važno je naglasiti i količinu. Očigledno su se u antičkom razdoblju eksploatirale veće količine sirovine odjednom, i to maksimalnom mogućom brzinom.

Kasnosrednjovjekovni i ranonovovjekovni kamenolomi pokazuju tlocrt oblika trokuta s kutom od 90° u najdubljem dijelu. Dobri primjeri su: otok Kamenjak kod Ista te Ovča na Dugom otoku. Tlocrt oblika trokuta posljedica je znatno manjih, pojedinačnih poslova, gdje se vadi samo nekoliko blokova u jednom redu koji čini jednu stranicu trokuta. Svaki novi segment vadi se iz druge stranice trokuta. Arheološki ostaci kamenoloma srednjega i ranoga novog vijeka definitivno pokazuju više manjih, pojedinačnih eksploatacija. Ova pojavu potvrđuje i više arhivskih spisa u kojima se vidi da srednjovjekovni majstori za određen posao sami organiziraju i vađenje i prijevoz kamenih blokova.

undoubtedly have suffered significant health problems. In the Middle Ages, this work was conducted by quarrymen, labourers, and apprentices whose apprenticeships lasted up to eight years. The reduction of the size of tools was to meet the requirements of the quarrymen of the time. The channel (*pašarin*) has been the most suitable system for extracting high-quality architectural stone in the modern era period. However, there have been no changes in the weight of the tools or the system of exploitation compared to the Middle Ages. Only the occurrence of gunpowder, hand drills, iron wedges, etc. is evident. These new techniques reduce the usability of the raw material and are used in parallel with classical techniques but rarely combined. Sometimes powder is used to break the upper layer of low-quality stone, while below it the exclusive use of hand tools continues.

The layouts of exploited quarries demonstrate another clear distinction. Antique quarries have a rectangular layout which is most clearly visible in the case of Kučićeva Kava, the classical antique quarries on Kamenjak near the island of Ist, and the quarry at the Padrare site on Dugi Otok. Such a layout is a consequence of a system of exploitation which imposes a regular size for quarrying. At the next stage, on the spot where the rock mass is of the highest quality, penetration into the new part of the open dig was carried out, which also had a right-angled layout. Apart from the system, it is also important to point out the quantity. Obviously, in the Classical Antiquity period larger quantities of raw material were exploited at the fastest rate possible.

Late mediaeval and early modern era quarries demonstrate layouts in the shape of a triangle with a 90° angle in the deepest part. Good examples of this are on the island of Kamenjak near Ist and Ovča on Dugi Otok. The triangular layout is a consequence of significantly smaller, individual works, where only several blocks were extracted in a row, forming one side of the triangle. Each new segment was extracted from another side of the triangle. The archaeological remains of mediaeval and modern era quarries clearly demonstrate several minor, individual exploitations. This phenomenon is also confirmed by several documents from which it is evident that mediaeval craftsmen organised both the extraction and transport of stone blocks for a certain job themselves.

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